Minnegram Winter 2014

Director's Corner

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Features

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- U of M researchers suggest complex relationship between phosphorus levels and nitrogen removal in lakes

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News

- Winter 2014 Legislative update
- Winter 2014 Community News
- Winter 2014 Student News
- Winter 2014 Resources and Publications
- Winter 2014 Upcoming Events

Minnegram

- Minnegram Spring 2015
- Minnegram Winter 2015
- Minnegram Fall 2014
- Minnegram Summer 2014
- Minnegram Spring 2014
- Minnegram Winter 2014
- Minnegram Fall 2013
- Minnegram Summer 2013
- Minnegram Spring 2013
- Minnegram Winter 2013
- Minnegram Fall 2015
- Minnegram Fall 2016
- Minnegram Spring 2016
- Minnegram Summer 2015
- Minnegram Summer 2016
- Minnegram Summer 2017
- Minnegram Winter 2016
- Minnegram Winter 2017

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nter 2014 Director's Corner

I can already feel the spring breezes blowing, in spite of the cold weather and December date….The reason is that I feel the growth and change that is being brought about by years of investments by the WRC in bring science to public engagement and policy in Minnesota - to the “real world”.

The Minnesota Water Sustainability Framework, commissioned by the state Legislature in 2009 and presented to them in 2011, is being implemented in nuanced but very discernable ways. I believe that this is due to the fact that the Framework initiated, facilitated, and pushed conversations (at times, uncomfortable conversations) about our water issues and their potential solutions. In my many interactions with water professionals across the nation, Minnesota is admired and envied for its progress and dedication to solving water resource issues. This success must be shared by our state legislators, our state agencies and local governments, our engaged citizens, and yes, the Framework. We as a state are moving, perceptively, towards sustainable water resources management.

We also held two highly successful conferences this fall – the annual Water Resources Conference at RiverCentre in St. Paul, and an innovative conference on Climate Adaptation Strategies for Communities. The latter is perhaps the inaugural of a series of future conferences that link scientific expertise to real-world approaches for local communities to deal with the inevitable climate change and uncertainty of the next several decades. This is a striking example of how research and science has informed public decision-making and planning, and grew out of the investments made by a dedicated partnership including the WRC, Extension, the Science Museum of Minnesota, state agency folks, and others over the last several years.

May your days be merry, and bright!

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n LaPara points to wastewater—and our treatment of it—as the culprit in antibiotic resistance

Animated in conversation and passionate about his research, Tim LaPara is the kind of professor who's not afraid to speak his mind or tackle conventional wisdom. Groundbreaking and challenging also applies to his research in the University of Minnesota's department of civil engineering, where he examines the relationship between wastewater treatment and microbial ecology.

An environmental engineer and professor in the Water Resources Science program, LaPara investigates how infrastructure can protect public health and the environment. His recent work has zeroed in on the most pressing threat to modern medicine—the rise of antibiotic resistance in the environment.

Addressing antibiotic resistance in the environment, "Poop is the real problem, or more specifically, our treatment of it," says LaPara.

"The current scientific paradigm is that antibiotic resistance is primarily caused by overuse of antibiotics, a theory which has led to initiatives to restrict antibiotic prescriptions and curtail antibiotic use in agriculture," says LaPara, who calls the recent push to limit the use of antibiotics in humans and animals "toothless" and one that doesn't address the problem at its source.

LaPara, instead, has turned the approach to the crisis on its head: "Poop is the real problem, or more specifically, our treatment of it," he says.

Even the most state-of-the art municipal wastewater treatment facilities are a major source of antibiotic resistant bacteria entering the environment, says LaPara. "Getting rid of antibiotic resistant genetic material at the wastewater treatment level is a new way of thinking about the problem, it's a totally different paradigm."

Antibiotic resistant bacteria develop in the gastrointestinal tracts of humans and animals taking antibiotics. The bacteria are shed through defacaection, most of which are collected by sewers connected to wastewater treatment facilities. Plants treat the sold waste portion of wastewater—called sludge—with anaerobic digestors powered by methane that raise the temperature of solid waste to 95 to 98 degrees.

“The trouble is, the current treatment process is too close to body temperature, the perfect environment for antibiotic resistant bacteria to survive and even grow,” LaPara says. While the liquid portion of the treated water is released in lakes and rivers, the majority of treated sludge ends up in landfills or in agricultural fields as fertilizer.

LaPara’s research found that exposing municipal wastewater solids to higher temperatures – to at least 130 degrees—destroys the genes used by the bacteria to develop resistance. Current technologies result in bacteria having a half-life in the order of a few days to a few weeks; LaPara’s research shows that heating sludge to 120-140 degrees results in a half-life of a few hours.

Retrofitting wastewater treatment plants to raise the temperature of digestion enough to kill the antibiotic resistance would be relatively easy and inexpensive to do, LaPara says. The infrastructure is already in place, as most wastewater treatment plants use self-generated methane gas to heat the sludge. While he’s optimistic that down the road, public health issues coupled by environment concerns will pressure change in the wastewater superstructure, he says, “Inertia is definitely a problem.”

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# of M researchers suggest complex relationship between phosphorus levels and nitrogen removal in lakes

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Editor's note: Jacques Finlay and Robert Sterner are Water Resources Science faculty

By Mary Hoff, editor, Ensia, Institute on the Environment

In the land of 10,000 lakes, one lake has been the starting place for research with implications for big lakes around the world. According to a study published online this week in Science, University of Minnesota researchers, building from studies of nitrogen levels in Lake Superior, uncovered a good news/bad news scenario for lake health that has long-term, global implications for pollution control efforts.

While many water-quality cleanup efforts focusing on the reduction of phosphorus have been highly effective, that success can also result in a decrease in microbial processes that remove nitrogen from water. Nitrogen accumulation in large lakes can lead to nitrogen pollution downstream, in rivers and coastal areas. The findings suggest that human-caused acceleration of global nitrogen and phosphorus cycles have boosted nitrogen removal processes in small to medium-size lakes. But in many of Earth's large lakes, these effects are reduced by successful control of phosphorus, resulting in nitrogen accumulation.

"Freshwater ecosystems, including lakes, streams and wetlands, are a large global sink for reactive nitrogen," says lead author Jacques Finlay, an associate professor in the College of Biological Sciences (CBS). "By reducing one aquatic pollutant – phosphorus – we are in some cases reducing the ability of lakes to remove nitrogen." Gaston Small, an assistant professor at the University of St. Thomas, and Robert Sterner, a fellow CBS ecology professor, co-authored the study.

To assess the influence of phosphorus on nitrogen removal, the researchers used a comparative approach – they examined the differences between how much nitrogen goes into lakes and how much comes out downstream – coupled with time-series analyses of nitrogen and phosphorus concentration in large lakes.

"The work was motivated by our thinking about the case of a single lake – Lake Superior. This lake is one that we would expect to efficiently remove nitrogen, but it doesn't, and it has extremely low phosphorus, so this work arose from efforts to generalize beyond a single system," Finlay says.

The excess nutrients can come from a variety of sources. City dwellers contribute nitrogen through sewage, lawn fertilizer, vehicle exhaust and pets. Farming represents the largest source in agricultural areas, and, in remote areas, air pollutants dispersing through the atmosphere can be a factor.

The study does not suggest we stop reducing phosphorus in lakes. "We need to pay attention to the way that nutrients interact in ecosystems and maintain our focus on reducing phosphorus and nitrogen pollution," says Finlay. "If we do that, we'll be taking steps toward improving water quality locally as well as downstream.

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Jim Stark presented Tuesday's plenary talk, "Water Sustainability in Minnesota: Today's Decisions Affect Your Grandchildren," addressing the projected decline in aquifers of as much as 40 feet, which is a problem throughout the state, not just the metro areas. Also of concern is well contamination, arsenic, a naturally occurring contaminate, and nitrate, a human induced contaminate. Future water sustainability will require thoughtful management of surface and ground waters in tandem. And the conversation needs to incorporate economics, politics, and as well as science. Water needs to be managed as a common good, and to do that says Stark, "We need to educate people outside of this room." And Stark pointed out, Minnesota needs an action plan, which it has in the Minnesota Water Sustainability Framework.

Tuesday's luncheon talk "Minnesota Draft Nutrient Reduction Strategy" was presented by Minnesota Pollution Control

Agency Assistant Commissioner Rebecca Flood. The strategy is intended to help reduce the hypoxia zone in the Gulf of Mexico by two-thirds. Flood defined hypoxia as depletion of oxygen within a water body brought on by excessive algal growth, caused by an overabundance of nutrients. Oxygen depletion imperils aquatic life and water quality. Currently, the zone is 15,000 square kilometers. All the states in the Upper Mississippi Watershed have been charged with reducing the amount of nitrogen and phosphates, key contributors to hypoxia, discharged into the Mississippi River. Minnesota will tackle the goal by targeting non-point nutrient sources including cropland and erosion, as well as point sources. The MPCA plan provides for measureable milestones along the way to reach the goal of a 45% reduction in nitrogen and phosphorous in the Mississippi by 2045. Monitoring programs already in place will measure progress. Minnesota will reap benefits from tackling the Gulf hypoxia issue by making its own water cleaner in the process. Read more about the MPCA nutrient reduction plan.

The Gulf hypoxia theme continued into the second day of the conference when Cathy Kling, professor of Economics at Iowa State University, presented “Agricultural Conservation Practices and Gulf of Mexico Hypoxia: A Model to Assess Costs and Trade-offs.” Kling provided an economic view of the problem of hypoxia in the Gulf, citing costs and tradeoffs involved in potential solutions to lessen the amount of nitrogen and phosphorous traveling down the Mississippi from the Upper Mississippi Watershed (UMWS). Kling described the Conservation Effects Assessment Project (CEAP) as an assessment of what society is getting for money spent on conservation techniques. CEAP created a model of the entire UMWS landscape, exploring what would happen if a variety of conservation combinations were employed, finding the least costly combination of conservation practices and using evolutionary algorithms to create different configurations in search of the lowest cost, effective program.

The outcome clearly showed that focused efforts, rather than sweeping implementation, worked the best in the model, at a cost of eight dollars per acre, or eight billion dollars annually. Kling also pointed out that these efforts would help the Gulf, but would not necessarily address water quality problems upstream in a given state.

Shawn Otto, local science advocate and author of Fool Me Twice, Fighting the Assault on Science in America was Wednesday’s luncheon speaker. The United States owes its riches to a respect for science as the foundation for research, knowledge and innovation. In recent times however, science has slipped into the murky waters of belief and opinion. Otto calls this “science denialism” and both political parties harbor their own faulty tenets. People left of center hold to beliefs that it fears could damage health and the environment, such as the unfounded claims that cell phones cause brain cancer and vaccines cause autism. The Right tends to dismiss global warming concerns as bogus and merely the means to create more burdensome regulations, and questions the theory of Evolution presented as scientific fact. Otto believes the Republican version of denialism is more damaging, as it attacks science itself, when scientific facts appear to disagree with party ideology. In this climate, Otto worries that citizens cannot be well-informed enough to make good decisions, as their decisions are more and more driven not by knowledge, but rather by whoever is most convincing. “When facts become opinions, the collective policymaking process of democracy breaks down,” says Otto. If the United States hopes to preserve democracy for future generations, we need “ . . .the common denominator (of) knowledge that can bring opposing sides together.”

Conference co-chair and WRC co-director Deb Swackhamer indicated that she had many positive comments about the

quality of speakers and balance of topics. “Each plenary speaker challenged us to think about ‘wicked’ topics, but each also offered a solution to the problem.”

Cathy Kling, professor of Economics at Iowa State University, pictured here with WRC co-director Deb Swackhamer, was Wednesday

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UM Climatologist Mark Seeley, Science Museum of Minnesota Director Patrick Hamilton, Water Resources Center co-director Faye Sleeper, and president of the Insurance Federation of Minnesota Robert Johnson, following Johnson

Summer is bringing more heat wave episodes, which directly affects our lives and livelihoods, as stressed livestock are less productive, lakes create an overabundance of algae blooms, stressing water wildlife, while air conditioning bills soar.

Seeley concluded that while we must adapt to the changing climate, it would be poor judgment to do nothing to mitigate the causes of climate change.

Atmospheric scientist Peter Snyder provided a primer on climate modeling, with the models showing an overall warming trend of three-four degrees uptick from 2080-2099, with winter temperatures rising five to six degrees in some places in Minnesota. The models also showed an increase in cloud cover, and a lack of snow cover both of which factor into higher overnight winter temperatures, as the bare ground radiates heat, which is then trapped under the blanket of

clouds. Snyder's models also predict more winter rain events, which will have a negative effect on businesses dependent on winter recreation.

Snyder acknowledged that there is much work to do on improving models as a tool, especially for predicting rainfall, and recommended that a multiple model ensemble would be more accurate than single models for future projections.

"I am not an expert on climate change," began Bob Johnson, president of the Insurance Federation in Minnesota, during his luncheon presentation. However, years of scrutiny of insurance claims in Minnesota have convinced him that our climate is changing. The spike in storm damage claims has increased insurance premium rates 267 percent higher between 1997 and 2010. The most common claims are hail, wind and water damage. Hail is the prime driver of cost, as replacement of roofs and siding is costly. Johnson contends the loss ratio for insurance companies is unsustainable.

Over the course of the afternoon, conference attendees heard speakers warn of retreating forests, higher human mortalities in urban areas, lakes suffering from lower water levels and increased nutrients, which means more plant life and less oxygen in the water, and more weather-related damage to infrastructure and roads.

Conference organizers were happy with the turnout for the conference. "We were very pleased that this conference filled a gap in understanding the impacts of climate adaptation in Minnesota. We look forward to next year's conference at a larger venue to continue to build a community of climate adaptation practitioners," said Faye Sleeper, WRC co-director and one of the conference planners.

The conference was produced by the Climate Adaptation Partnership, with assistance from the University of Minnesota's Water Resources Center, The Science Museum of Minnesota, University of Minnesota Extension, The McKnight Foundation, the Freshwater Society, the University of Minnesota's Regional Sustainable Development Partnerships, Minnesota Department of Health, Minnesota Sea Grant, Minnesota Pollution Control Agency, Minnesota Association of Soil and Water Conservations Districts, and the Minnesota Department of Natural Resources.

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RC Research Associate Paul Bourget creates roadmap for water resources training guide website

By Paul Bourget

Editor's note: Paul Bourget spent this past year at the Water Resources Center working on the Water Resources Training and Education website, in partnership with the Army Corps of Engineers Institute for Water Resources.

The Water Resources Training and Education website is under initial development to inform prospective students in the U.S. of training opportunities in the field of water resources, from government-sponsored short courses to graduate studies.

The stimulus for this project stemmed from a need identified within the U.S. Army Corps of Engineers to encourage members of its planning community to pursue graduate-level work. This need was one of the findings of an earlier "Planning Excellence" task force that was formed to improve the level of expertise within that particular group. Planners within the Corps were experiencing workforce attrition within their ranks, while simultaneously being asked to assume new responsibilities. Corps planners were facing new challenges in areas such as public participation and multi-objective analyses. It was therefore felt that the planners as a whole needed to be exposed to emerging water resources challenges within an academic setting in such diverse areas as policy development, participatory planning, applied economics and new modelling methodologies.

The training opportunities that exist within water resources have grown appreciably since that task force deliberated in the early 2000's, encompassing a variety of inter-disciplinary tracts and training institutions. A field that was previously dominated by engineers and hydrologists has become much more inter-disciplinary in nature and a wide variety of universities and other learning centers have developed a combination of specialized and generalized curricula to meet the demands for a field that continues to evolve. Prospective students, ranging from those who are just starting out to seasoned professionals, now have considerable options for pursuing water resources training, from simply honing their professional

skills in a particular area to providing a solid interdisciplinary foundation. Practitioners, for instance, now have the ability to obtain a variety of on-line professional and academic certificates that were non-existent a few short years ago.

The Water Resources Training and Education website, therefore, serves as a roadmap of sorts that allows students to make informed decisions on what training tracts might best match their interests. Although it was designed with the Corps' planning community in mind, the site's content is not restricted to the needs of that one organization. Should this information portal prove to be sustainable, there is potential for expanded development in areas such as serving as a useful tool to promote staff exchanges, assisting in the conduct of gap analyses of study areas, facilitating research collaborations, posting training announcements, and promoting inter-institutional course sharing.

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nter 2014 Legislative update

By Deb Swackhamer

We are hopeful that we will have certainty in our Federal budget sometime in January. We have been living with continuing resolutions and automatic sequestration cuts for two years, so this is very welcome if still not ideal. The budget committee chairs of the US House and Senate have agreed to a plan, the Bipartisan Budget Act and the House and Senate have passed it. Hopefully, Congress will complete the process of passing a spending bill in early January, one that would consist of an omnibus bill that includes all twelve spending bills for all aspects of the Federal budget. The spending bills crafted in both the House and Senate appropriations subcommittees that fund the USGS budget include funds for the WRRI program, so we are optimistic.

Should we have a federal FY14 budget next month, we are hopeful that we can re-engage the Congress on a formal reauthorization of the WRRI program.

On the state level, this past month we celebrated the fifth anniversary of the passage of the Clean Water Land and Legacy Amendment to the Minnesota Constitution that created the Clean Water Fund. We are pleased to report that many recommendations of the Minnesota Water Sustainability Framework have been implemented, due to collective actions on the part of the Legislature, the Executive Branch, and others. Progress has been made on all ten “Big” issues, although some more than others. We eagerly anticipate the Clean Water Fund Performance Report 2013 (an assessment of key indicators of how we are doing, due out this January) and the Clean Water Fund Roadmap (a high level look forward of where we want to be, anticipated in April 2014).

The WRC designed and sponsored a full-day short course on “water 101” – a series of lectures on water issues and challenges in Minnesota, federal and state water policy, and water policy analysis. The goal of this short course was to develop expertise and leadership in water resource issues in state decision-makers, and was done with support from the

National Caucus of Environmental Legislators in Washington, D.C. The short course was held at the University of Minnesota in September and open to all Minnesota State Legislators and their staff. A condensed version was presented to the Legislator-Citizen Commission on Minnesota Resources (LCCMR) in December.

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William Arnold (WRS faculty, CE) was the 24th Leonard A. Ford Lecturer in the Department of Chemistry at Minnesota State University-Mankato October 28, 2013. He spoke on From Triclosan to Dioxins: How your hand soap leads to an unanticipated environmental problem. Arnold was recently recognized as a “super reviewer” at the journal Environmental Science and Technology where he is also an associate editor. Arnold is on sabbatical at the Woods Hole Massachusetts Oceanographic Institution in the Department of Marine Chemistry and Geochemistry through June 2014.

Les Everett (WRC) presented a poster titled "Manure application guided by grid soil sampling: Minnesota case studies," at the national conference of the American Society of Agronomy in Tampa, Florida, November 3-6, 2013. The poster was selected as one of the top three Extension poster presentations. It summarized a WRC-led project that resulted in eight case studies available on the UM Extension Manure Management and Air Quality website. **Jose Hernandez** and **Randy Pepin** (UM Extension) were co-presenters. Funding for the project was provided by the McKnight Foundation.

John Gulliver (WRS faculty, CE) is spending the year working with visiting Valparaiso University professor Peter T. Weiss on Gulliver's research group on treating stormwater runoff.

Lucinda Johnson (WRS faculty, NRRI), is serving on a panel of the U.S. Environmental Protection Agency Science Advisory Board that will review a long-awaited study on water “connectivity” that is expected to inform a pending jurisdiction policy. According to the EPA’s website, the proposed rule “will provide greater consistency, certainty, and predictability nationwide by providing clarity in determining where the Clean Water Act applies.” The draft science report, Connectivity of Streams and Wetlands to Downstream Waters, will provide the science-based information to clarify Clean Water Act jurisdiction, “including a description of the factors that influence connectivity and the mechanisms by which connected waters affect downstream waters,” the website states.

Gary Sands (WRS faculty, BBE) gave a keynote presentation entitled Drainage System Design for Multiple Objectives at a

symposium conducted in September 2013 by the Association of Nordic Agricultural Scientists, in Sarpsborg, Norway. The question being addressed by the symposium was, “Does climate change demand a new approach to drainage design”, and Sands’ keynote outlined the challenges of multi-objective drainage design, wherein trade-offs are sought among traditional agricultural productivity/profitability objectives and mitigation of environmental impacts associated with drainage systems. The three-day symposium was attended by agricultural scientists and engineers from the Nordic and Baltic countries.

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nter 2014 Student News

Megan Kelly received her Ph. D. in August 2013. Her dissertation was titled: The environmental fate of the phytoestrogens genistein and daidzein. Kelly was advised by **William Arnold**.

Jennifer Meester received her M. S. degree in September 2013. Meester was advised by **Martin Saar**.

Molly O'Beirne received her M. S. degree August 2013. Her thesis was titled: Anthropogenic Climate Change has Driven Lake Superior Productivity Beyond the Range of Holocene Variability: An Organic and Stable Isotopic Study of Human Impacts on a Pristine Biogeochemical System. O'Beirne was advised by **Josef Werne** and **Erik Thorson Brown**.

Benjamin Underhill received his M. S. degree in August 2013. His thesis was titled: The Influence of Vegetation and Root Density on Erosion for Three Streams in Minnesota. Underhill was advised by **Chris Lenhart** and **John Nieber**.

Molly Wick received her M. S. degree in October 2013. Her thesis was titled: Identifying Erosional Hotspots in Streams Along the North Shore of Lake Superior, Minnesota using High-Resolution Elevation and Soils Data. Wick was advised by **Karen Gran**.

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nter 2014 Resources and Publications

Phytoestrogens in the environment: I. Occurrence and exposure effects on fathead minnows

Rearick, D.C., N. T. Fleischacker, M. M. Kelly, W. A. Arnold, P. J. Novak, H. L. Schoenfuss.

2013. Environmental Toxicology and Chemistry.

Phytoestrogens in the environment: II. Microbiological degradation of phytoestrogens and the response of fathead minnows to degradate exposure

Kelly, M.M., N. T. Fleischacker, D. C. Rearick, W. A. Arnold, H. L. Schoenfuss, P. J. Novak.

2013. Environmental Toxicology and Chemistry.

One electron oxidation potential as a predictor of rate constants of N-containing compounds with carbonate radical and triplet excited state organic matter

Arnold, W.A. 2013. Environmental Science: Processes & Impacts. http://dx.doi.org/10.1039/C3EM00479A

Impact of organic carbon on the biodegradation of estrone in mixed culture systems

Tan, D.T., W. A. Arnold, P.J. Novak. 2013. Environmental Science & Technology. http://dx.doi.org/10.1021/es4027908

Experimental Averaged Free-Surface Profiles and Turbulence Characteristics in Skimming Flows

Simões A, H.E. Schultz, R.M. Porto, and J.S. Gulliver Journal of Water Resource and Hydraulic Engineering, 2(1), 1-12, 2013.

Mechanisms for removal of perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) from drinking water by conventional and enhanced coagulation

Xiao, F., M.F. Simcik and J.S. Gulliver. Water Research, 47(1), 49–56, 2013.

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Water Resources Center | 173 McNeal Hall | 1985 Buford Avenue | St. Paul, MN 55108
612-624-9282 | umwrc@umn.edu

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